All Roads Lead to Broadband...

Continued from Page 8

If current statistics are any indication, consumers already seem hungry for the broadband experience. Digital Technology Consulting estimates that, through the end of April, there were roughly 3.0 million North American subscribers to high speed Internet services, including both cable modem and Digital Subscriber Line (DSL) households. That number is likely to double by the end of this year and approach 10 million homes by the end of 2001. North American cable operators alone are now installing more than 7,000 new cable modems per day.

"We see digital media as that killer app," driving that subscriber growth, says Michael Aldridge, product manager for Microsoft's digital media division. Early efforts and music and video streaming -- albeit at low bit rates with resulting limited quality -- whet the public's appetite for the growing flow from broadband streaming media services. "The demand is massive out there, and it's clear that we are reaching a critical mass."

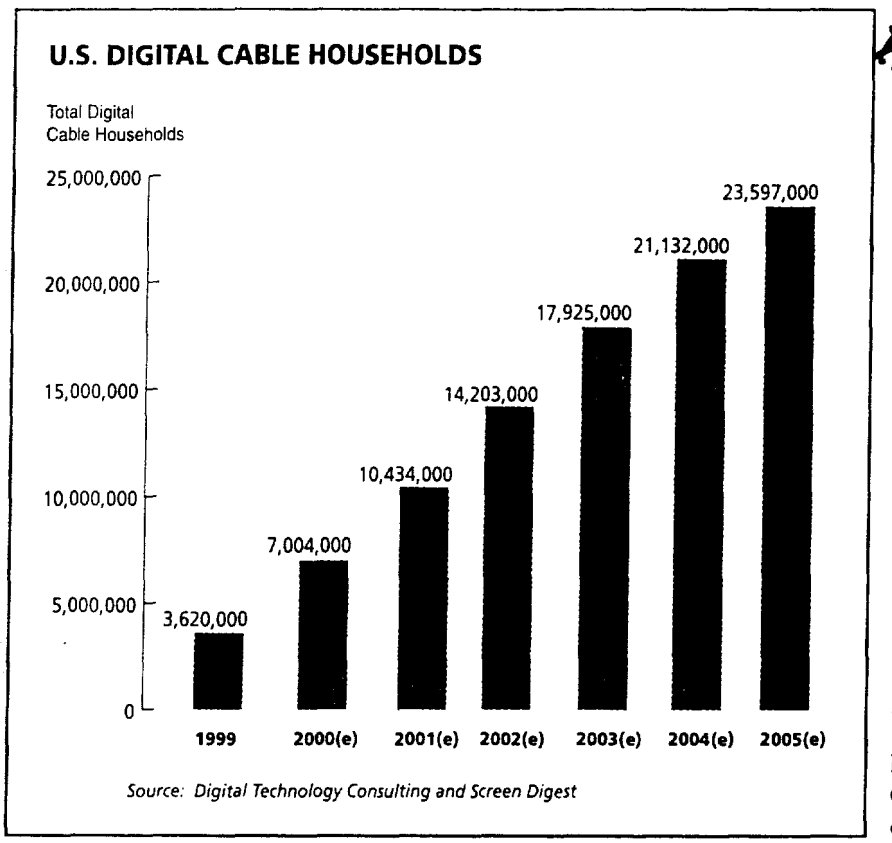
If there's a bottleneck, he argues it's not in the underlying technology, but the infrastructure providers' ability to get the public wired. "They're way behind in hooking people up," he says. "They're oversubscribed and limited in their capacity to get it done."

There are other issues, of course, from the cable perspective as to how quickly broadband can roll out, one of which is caching content closer to the edge of the network. Not only will that require cache engines able to store large amounts of streaming media, but it will also require new business relationships with content providers.

IP-based video streaming is of such poor quality, asserts Cox Communications senior vice president of engineering Alex Best, the only way cable modem subscribers will see a high-quality stream is if the content is cached at the operator's headend. "We have the bandwidth in the last mile, but the Internet backbone and transport mechanism do not have the capacity to support high quality streaming. The only way to resolve that is to store the content in our headend." And that, he says, will require a series of negotiated business relationships between ISPs and cable operators.

Trying to deliver the kind of video quality you get in a cable plant with IP is very difficult," agrees SeaChange's Gerovac, citing server limitations, unresolved protocol standards for handling data streams for different applications, and the strai on the Internet's long haul n works. It all comes down to t same video issues cable operat are confronting with video-o demand and other advanc interactive services. "[It's a about] the degree to which y can deliver dedicated [vide streams without contention."

And the cable industry intensifying its efforts to crea two-way fiber-rich networks th will accommodate broadban media to the PC and to the tel vision. As future iterations digital cable set-top box include high-speed modems, th universe of households subscri ing to digital cable services – est mated to exceed 7 million b year's end – could be consumin streaming media in the futur **(see chart on left).** Digit Technology Consulting estimat that universe could rise to 23. million U.S. households by 200



Two-Way Transmissions in DTH Satellite Future

While satellite delivery o broadband is lagging behin cable modems and DSL, it's jus a matter of time before that, too becomes an effective broadban delivery mechanism. Bot DirecTV and EchoStar, the tw dominant U.S. DBS servic operators have made significan commitments to high-spee Internet services — includin DirecTV's sister DirecPC servic and EchoStar's planned two-wa service applying technolog licensed from an Israeli hig tech start-up.

EchoStar will roll out its firs

Continued on Page 1

Streaming Media Opportunity for Cable

The increasing demand for rich media entertainment, coupled with new forms of advertising and communication, are creating exciting opportunities for cable operators. Cable operators are positioned to capture significant new revenue from services that stream media into homes. The term streaming media refers to audio or video that is streamed over a network. This technology, created for Internet purposes, augments the Moving Pictures Experts Group (MPEG)-2, Transport Stream (TS)-based digital video infrastructures currently deployed by many operators.

Cable operators are positioned to be first to offer advanced streaming-media services in the home and first to create broadband portals that can be oriented for television and PCs. Incremental revenue gains for cable multiple system operators (MSOs) who develop streaming-media platforms will dwarf the incremental costs of building the necessary infrastructure. Streaming-media platforms will leverage much of the infrastructure that MSOs are putting in place for other services, such as high-speed data, digital television, and voice.

This paper takes a look at the business case for streaming media, including the environment, business models, and methods for revenue generation. It also describes the architecture and the technologies that will enable cable operators to adopt streaming media to increase revenues. Streaming media will significantly change both the cable environment and opportunity, and this paper will show you just how significant those changes will be.

The Emergence of Streaming Media

Streaming media was developed to allow Internet users to experience rich media without having to first download entire pieces of video or audio. When it first appeared in 1995, many felt that the Internet would never carry even low-quality audio signals. Today, near-CD quality audio is available from many Web sites, as evidenced by MP3.com's audio content on the Internet. More than one million digital music players have been shipped in 1999 (Forrester Research) and more than 100 million streaming media players have been downloaded (Real Networks, Microsoft, Apple). PC users account for most of the streaming media players. However, streaming media will start to reach television audiences, as interactive set-top boxes (STBs) begin to reach homes this year.

The presence of streaming media on the Internet is increasing because new supporting technologies can meet demanding user expectations. Streaming media is transported over IP. The broadband IP infrastructure is already in place to allow high-speed data services with cable modems. At the same time, STBs with two-way IP-channel capabilities are being deployed. By 2002, the number of advanced, fully interactive digital STBs will reach over 16 million units worldwide (Yankee Group, January 1999 and Datamonitor, January 1999).

Today's streaming media Compression/Decompression Modules (CODECs) are optimized to deliver better video quality at lower bit rates. While still not comparable in quality to MPEG-2's 3-Mbps to 8-Mbps rates, new CODECs deliver reasonably good video quality in the mid-band range, from 300-kbps up to 1.5-Mbps—and "reasonably good" is proving good enough to offer high-value, personalized, localized, and interest-targeted content to sizable subscriber segments.

Another key streaming media enabler is content availability. Content developers are creating new products using streaming media technology and are making them available on the Web. New streaming media content includes news, advertising, music videos, weather, education, archives, e-commerce, and community information. Portals hosting streaming media are growing, because the addition of streaming media increases users' interest in the content they receive. According to Dataquest, 29-percent of all U.S. businesses will incorporate streaming media on their Web sites within the next two years. The potential for entertainment-oriented streaming media is growing. With their high bandwidth, high-reach infrastructure, cable operators are the best candidates to capture this new content and deliver it to the widest audience.

Streaming Media Business Models

According to Paul Kagan Research, streaming media-related revenue will grow to more than US$1.5 billion by 2002, reaching US$12 billion by 2008. In 1999, there were roughly 9.8 million streaming media viewers. Each streaming media session averages seven minutes per stream. Paul Kagan Research predicts that this will grow to 16.6 million viewers at 12 minutes per session in 2000 and 42.8 million viewers at 14 minutes per session by 2002. New revenues will come from streamed program ads, sponsorships, affiliate fees from merchandising and e-commerce, Web pay-per-view, and Web pay-per-play.

Because of the broad growth potential that streaming media demonstrates, MSOs can tailor streaming media for many different business models. It can be a way to increase customer loyalty, but it can also serve as the foundation for appealing new services that can expand current cable offerings. Streaming media becomes even more important when subscribers access the Web through STBs and display the Web on their television sets. Video and audio enhance the Web experience for television audiences. That enhanced experience can result in higher customer loyalty to cable high-speed data services along with the potential for additional revenue.

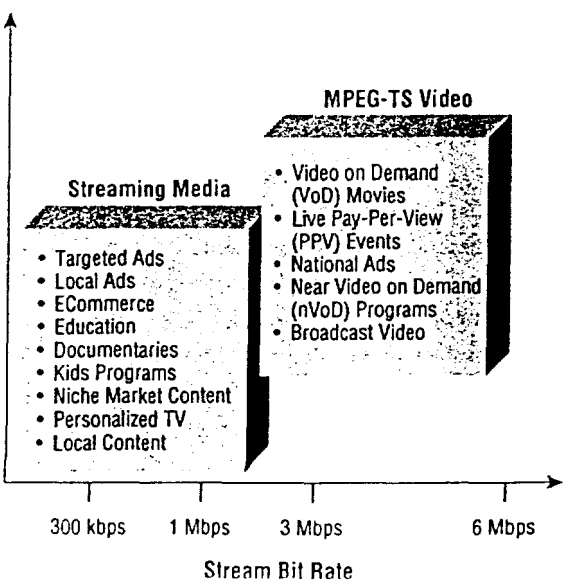
Creating Customer Loyalty with Streaming Media

Streaming media enables cable operators to create subscriber loyalty for their high-speed data service. Because cable can deliver a tremendous amount of bandwidth, cable operators can offer better-quality Web experience, using streaming media, than other Internet service providers (ISPs). Cable networks ensure that content resides closest to users, assuring the highest-quality user experience. With streaming media, even if ISPs team up with Digital Subscriber Line (DSL) providers who have limited bandwidth or Digital Broadcast Satellite (DBS) providers who offer one-way broadcast services without interactivity, cable operators can ensure that their offerings remain highly competitive.

Creating New Classes of Programming with Streaming Media

Streaming media enables cable operators to broaden and enrich their current subscriber offerings to include targeted advertising, personalized TV, local community programs, and niche market programming. Short video clips can be stored, assembled, and delivered to subscribers based on user profiles and requests; video content can be mixed with live broadcast TV and Web pages. Impulse e-commerce offers a fast, convenient way to purchase products via TV (see Figure 1).

Figure 1 Multiple Complementary Business Offerings for Cable Operators



Targeted Advertising

Targeted advertising will become a significant revenue source for cable operators. With interactivity, cable operators can help advertisers target specific audiences and achieve better hits and retention. Additional value means cable operators can obtain additional revenue from advertisers. Streaming media also offers a great way for cable operators to advertise other broadcast offerings, such as movie trailers for new releases.

Personalized TV

For news and information, more personalized and targeted content has great consumer appeal. Everyone has choices and opinions about news, weather, finances, hobbies, and even music videos. Programming, using streaming media, can be personalized for individual viewers. Each can have a personal channel that gives them what they want when they want it.

Because streaming media is delivered over an interactive IP network, cable operators can collect statistics and quickly create highly accurate demographics. Then, it's easy to target and advertise content to viewers who would be most interested.

Personalized TV is an extremely compelling platform for e-commerce. When viewers see the products or services in video, motion and action demonstrate proof of claim and create more excitement and urgency to buy more rapidly than text or graphics.

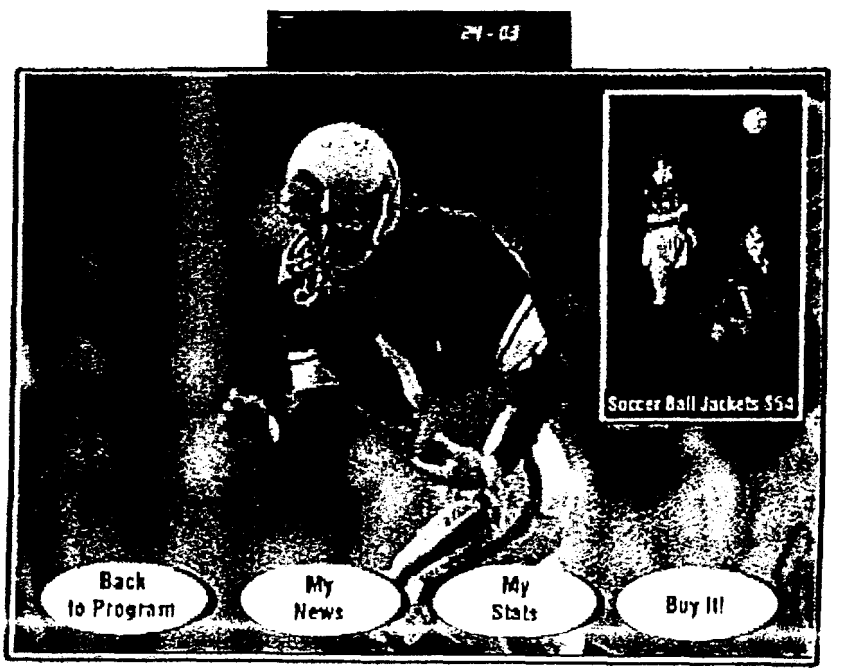
Localization

Inserting local content, including advertisements, news, or weather into regional or national broadcasts is very compelling, and streaming media makes it easy. With IP-based routing and switching, insertion of streaming media as local content for any particular subscriber is easily achieved. Rather than confining subscribers to a standard broadcast schedule, this approach also lets subscribers access the programs when they want.

Niche Market Programming

With streaming media, cable operators can offer content providers additional channels of distribution for content that doesn't have wide appeal but are compelling for certain audiences. For example, streaming media over the Internet can be a showcase for movies, short subjects, and animation that have historically fallen through the cracks. The Internet can also become a mass-market test-screen and an alternative distribution channel for filmmakers and artists who offer alternative music and entertainment. Broadcast.com, atomfilms.com, payforview.com, Trimark, and NewVenue are already forging alliances for streaming media content. Programs that address special interests and hobbies, such as wine tasting, cooking, dance instruction, little league, and home improvement are also potential niche market programs (see Figure 2).

Figure 2 Example Program



Archived Content

Archives of older content and hard-to-find footage—old movies, documentaries, or cartoons, for example, are another interesting and profitable use for streaming media. Streaming media enables on-demand selection for viewers in a very cost-effective and scalable manner.

Education

Because of the flexibility that streaming video brings, there are additional market segments that cable providers can consider entering. Education and distance learning are both profitable potential markets for cable operators.

Education in the home, from grades kindergarten through graduate and extension programs, is an important trend that streaming media can support. Cable operators can offer supplemental materials for home schooling, as well as graduate and extension programs in partnership with local school districts and universities. Children's channels, special education, and MBAs can all work well with interactive streaming media.

Generating Multitiered Service Revenues with Streaming Media

Today, subscribers generally pay a monthly subscription fee for cable services. Streaming media, and the content it can deliver, enable several additional ways to generate more revenue. A tiered approach to content availability, indicating differentiated services and speeds, is one option. Streaming media offerings allow cable operators to offer multiple tiers of services, differentiated by access speeds (such as 256-kbps at tier 1, 512-kbps at tier 2, and 768-kbps at tier 3). Fielding portions of the cable provider's walled garden as streaming media with impulse buys as an up-sell are another opportunity. Viewers can enter the wall garden, where certain streaming media offering would be available without charge, while others would be available as upgrades to the next tier, as pay-per-view offerings, or as viewable for specified, priced time periods.

Pay-per-view is another path to streaming media revenue. Live and prerecorded events can be streamed to customers for a fee. The events chosen for pay-per-view treatment can range from Webcast fashion shows to concerts. Bandwidth allocation and the ability to apply content access control enables cable operators to allow these Web events at certain subscription levels or as pay-per-view style events.

Targeted advertising and e-commerce will also be important new sources of revenue. Advertising can be delivered as streaming media content that is triggered or synchronized with broadcast MPEG-2 content to allow higher interactivity and targeting. Advertising that draws consumers into the e-commerce environment is an ideal way to drive impulse buys. Cable operators can earn a percentage of the e-commerce transaction, as well as revenue for the advertisements themselves.

Subscriptions, transaction-based fees, pay-per-view fees, and upgrade services as part of subscriptions are all potential sources of revenue. What works depends on demographics, geography, culture, and content—but it's obvious that streaming media, with its inherent flexibility, can make the most of each opportunity.

The Streaming Media-over-IP Solution

IP-based networks offer cable companies the opportunity to offer multiple services using a common infrastructure. IP networks, based on Cisco technologies, are the most advanced, flexible, and cost-efficient solutions available for delivering streaming media over cable. They enable many cable offerings in both mid-band and broadband ranges and are designed to leverage the common infrastructure cable operators already have in place by optimizing both time to market and profitability in developing, deploying, billing, maintaining, and expanding cable-based services over time.

Achieving the right cost and quality efficiencies is possible only by ensuring a high degree of intelligence in the cable network, where bandwidth management is extremely valuable. When considering the implementation of streaming media as part of a cable operator's business, it's important to plan for scalable content distribution, capacity, quality of service (QoS), standard transport signaling, security, and lowest cost to ensure that the infrastructure can be successfully leveraged to generate new sources of revenue.

Cable Network Architecture for Streaming Media

This architecture was developed to enable the technical flexibility that lets cable operators grab new revenue opportunities quickly:

- New services and devices can be added rapidly, since a separate infrastructure does not need to be created and protocols over a unified infrastructure are standard.
- It's easy to handle unpredictable service demand and growth because bandwidth is available in a single, flexible pool rather than as a static allocation coming from several, incompatible infrastructures.
- A shared infrastructure to support multiple services reduces both operational and capital costs.

Figure 3 Streaming Media Architecture

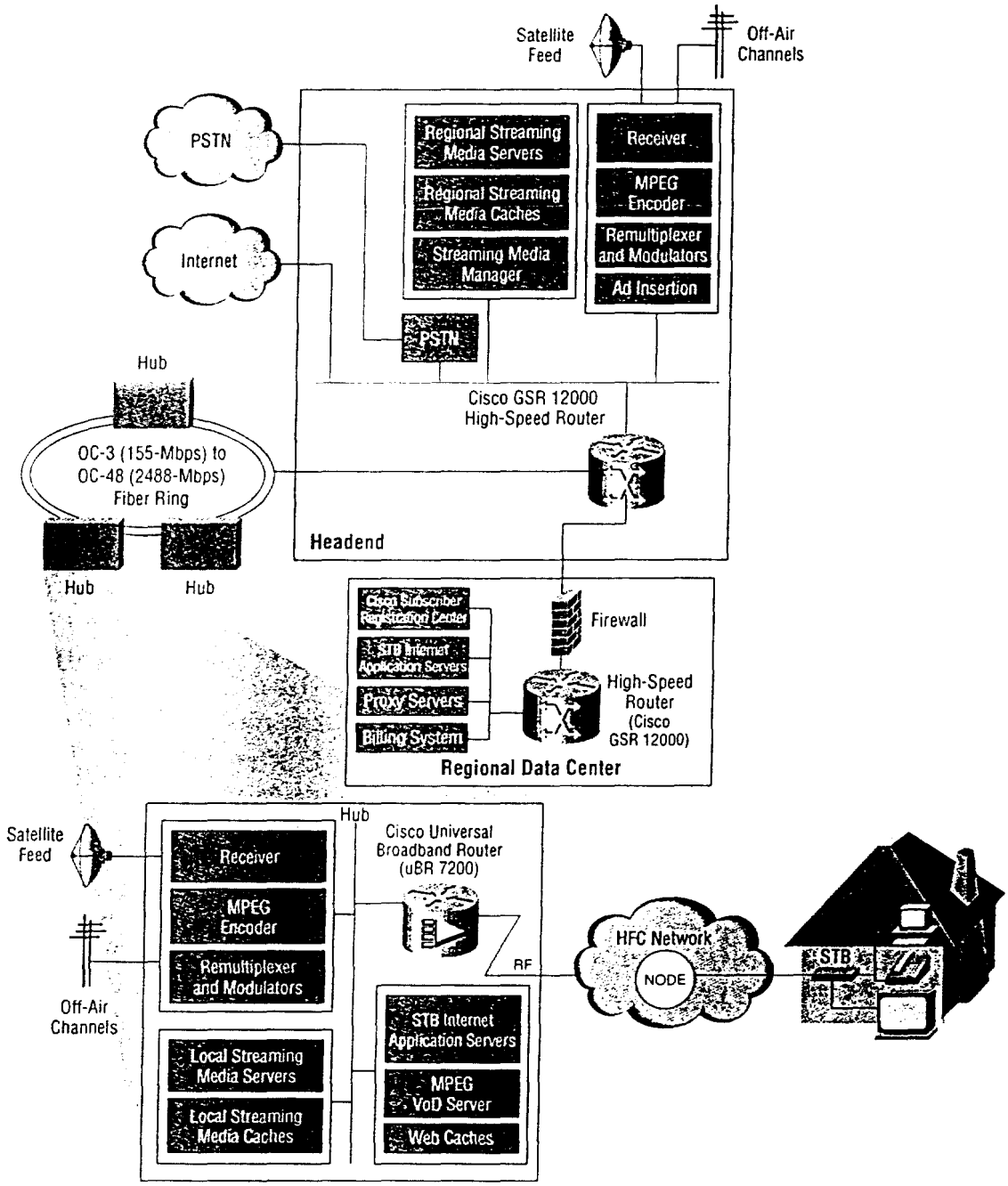


Figure 3 illustrates the Cisco cable network architecture for streaming media. The cable headend brings national and regional content, including satellite and off-the-air video, the Internet backbone, voice, and dial access to the cable network. The headend reformats this content to be sent to hubs over the high-speed optical fiber network. Each hub on the fiber network serves approximately 10,000 to 50,000 homes passed. The hub combines regional programming with local content, sending the combined content to the hybrid fiber coaxial (HFC) cable network.

The HFC network distributes this content to subscriber devices, including cable modems and STBs. Interfaces on a digital STB allow connection to a television, one or more personal computers via Ethernet, and one or more telephones

for voice-over-IP (VoIP) telephony. The regional data center, often located at the headend or connected to the headend with a high-speed fiber network, contains STB and cable modem provisioning servers (such as the Cisco Subscriber Registration System [CSRC]), STB Internet Application servers that bring Internet services to the television, and billing and proxy servers.

Content Distribution

The regional headend and local hubs form a two-level content distribution hierarchy that is well-suited for streaming media delivery. High-demand content should be located as close to the subscriber as possible to reduce the bandwidth demands of streaming media in the backbone network. The two-level cable network hierarchy provides an efficient content-distribution hierarchy where high-demand content is served by each local hub, while less popular content is available at the headend on an on-demand basis.

Each local hub contains a cluster of streaming media servers and cache storage devices, and can intelligently balance the load across these servers for optimum performance and reliability. Local caches store popular content and also have sufficient room to cache on-demand content when necessary. The headend contains streaming servers and caches and typically serves the hubs. It also contains a streaming media manager that handles initial streaming content requests from subscribers, maintains a directory of all server contents, and ensures they are up to date.

When a subscriber requests streaming content, such as a newly released music video, the request is first sent to the streaming media manager at the headend. The manager communicates with the billing system to authenticate the subscriber and to determine the allocation of bandwidth based on the service plan selected by the subscriber and the particular piece of content requested. It may also contact the origin server to obtain authorization for the requested content. Then, depending on the popularity of the stream, one of the following three scenarios can take place:

- *Scenario 1*—If the stream is very popular and already cached near the subscriber, the streaming media manager redirects the subscriber's request to the streaming media server located at the corresponding hub. This local streaming media server establishes a connection with the subscriber's device (typically a PC or a set-top box) to initiate content streaming.
- *Scenario 2*—If the content is not cached at the hub but is available at the headend, then the streaming media manager directs the headend servers to stream that particular content to the hub cache and then directs the hub server to stream this newly available content to the subscriber. Depending on the network architecture, bandwidth utilization, and caching policies, the headend server may directly serve the stream (bypass hub servers and caches) or the local server may intercept the stream from the headend cache (bypassing the hub cache).
- *Scenario 3*—If the content is not cached at the hub or at the headend, then the streaming media manager directs the headend server to retrieve this content from the original (for example, the music studio's) Web server. Once the content is cached at the headend, the subscriber's request is fulfilled, as described in the second scenario.

Web Cache Control Protocol (WCCP) is supported by most Cisco IOS® routing platforms and the leading cache vendors in the industry. A WCCP-enabled router can analyze Web requests and based on TCP port number, can transparently redirect the request to a caching server instead of the intended origin server. This way, the cache can service all subsequent requests once content is stored locally, maximizing access performance while minimizing unnecessary bandwidth consumption.

Capacity Planning

Capacity planning in this environment can be relatively simple. In North America, where Data Over Cable System Interface Specification (DOCSIS) and 6-MHz channel widths are prevalent, each data channel in the HFC network has 27-Mbps (QAM64) or 38-Mbps (QAM256) bandwidth. Assuming 300-kbps streams, that becomes 90 concurrent streams per QAM64 channel or 126 concurrent streams per QAM256 channel. If 16 DOCSIS channels are allocated for streaming media, that means 1440 concurrent streams for QAM64 or 2016 for QAM256. Assuming a hub that serves 20,000 homes passed with 65-percent penetration and 50-percent with two-way interactive service, this capacity can serve on-demand streams from 22-percent penetration for QAM64 to 30-percent penetration for QAM256. In Europe, and the rest of the world, 8-MHz channel widths are prevalent, the bandwidth available is even higher. In addition, the cable operator can also change the combining ratio at the

nodes to provide higher bandwidth. Since streaming media is sent using standard IP protocols, the bandwidth can be shared with other applications

Quality of Service

A critical consideration when designing streaming media networks is quality of service (QoS). To deliver a consistent, high-quality user experience, the network must maintain a given stream's specified latency and throughput requirements. Though end-to-end QoS for streaming content is generally difficult to guarantee over the public Internet, it becomes more manageable over a DOCSIS-based private cable network. In the HFC network segment, from local hub to subscriber STB, QoS is achieved with dynamically provisioned service flows specified under DOCSIS.

On the optical backbone network segment, from the headend to the hub, QoS is achieved using either Differentiated Services (Diff-Serv) or Resource Reservation Protocol (RSVP), or through a combination of both. Diff-Serv classifies packets into a few aggregated classes, using the type of service (ToS) bits of IP packets, with different priorities. Diff-Serv routers can then shape traffic using weighted fair queuing (WFQ) to queue streaming media as preferential class traffic ahead of other best-effort class traffic.

In addition to Diff-Serv, Resource Reservation Protocol (RSVP) reserves bandwidth on a per-data-flow basis through the entire network. The router can then grant the reservation request for the streams, as long as the request does not conflict with available resources and policies. This guarantees QoS and bandwidth reservation at a fine-grain level.

Diff-Serv and RSVP are both Internet Engineering Task Force (IETF) standards and Cisco offers end-to-end support for Diff-Serv and RSVP.

Standard Transport Signaling

While Diff-Serv and RSVP can guarantee appropriate QoS for a real-time service, it is also important to address network-induced jitter. Real-Time Transport Protocol (RTP) (defined in IETF RFC 1889) helps to eliminate jitter caused by the queuing delay between routers for real-time services. RTP ensures reliability and better video quality for streaming media using the time stamps to synchronize the clock between the source and destination and sequence numbers to ensure the correct order of packets. The Real-Time Streaming Protocol (RTSP) (defined in IETF RFC 2326) is the standard protocol for stream control between the video server and the client device. Together, RTP and RTSP are important standards to ensure robust delivery and signaling for streaming media.

Security and Access Control

Security is important to all networks. In the context of cable and streaming media, it's critical to be able to manage and account for data flows. The network can use committed access rate (CAR) and access lists to manage admission control at the edges of the network. Admission control must be enforced to ensure consistent user experience and prevent unauthorized or unpaid use. The network must also operate as an accountant, metering the usage using tools, such as NetFlow, and passing that information to billing systems. Networks designed using advanced Cisco networking components are able to control which traffic is allowed onto the network and provide detailed accounting information on the traffic that is allowed.

Benefiting from the Infrastructure

Cisco provides key components to enable streaming media over cable networks. For the headend, the Cisco GSR 12000 Gigabit Switch Router (GSR) Series enables an IP layer directly over the optical infrastructure and delivers Cisco dynamic packet transport (DPT) technology for reliable, bandwidth-efficient transport over fiber. The Cisco uBR 7200 universal Broadband Router Series at the hub combines the powerful Cisco 7200 router and a cable modem termination system (CMTS) in one integrated platform, providing a scalable, feature-rich interface between subscriber devices and the backbone data network. Both of these Cisco routers run the Cisco IOS software, which provides a seamless, end-to-end implementation of the aforementioned QoS features, WFQ, standards-based signaling, and protocols to provide a complete networking solution for streaming media. Cisco also provides networking products for load balancing, such as LocalDirector and DistributedDirector. The Cache Engine 500 series, along with the load-balancing components WCCP, direct streaming media requests appropriately.

The Cisco Streaming Media Solution:

A Direction for the Future

High-capacity cable networks, growing interactive cable capabilities, and access to vast content resources all work together to uniquely position cable operators to offer a wide variety of new streaming-media-based services. Cable operators can meet the needs of both television and home PC users with streaming media. Targeted advertising, personalization, localization, niche content, the redeployment of archived materials, education programming, and e-commerce are all viable new services for cable operators. Multiple models for revenue generation include use fees, subscriptions, advertising, and time-based billing. The time is right to deploy new services in the streaming media arena.

Streaming media is also the vehicle that will enable cable operators to effectively differentiate themselves from competitive providers with less bandwidth.

Cisco has created an IP architecture for cable operators that leverages the common infrastructure already available to optimize time to market and profitability in developing, deploying, billing, maintaining, and expanding these services over time. Working with Cisco will ensure the highest infrastructure reliability while guaranteeing the kind of network intelligence that makes differentiated services possible.

If you want to know more, contact your local Cisco sales office, or visit www.cisco.com/cable.

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Interactive Cable Is a Reality: Liberate Technologies and Cisco Working Together

Interactive cable is no longer just a promise. Today—cable providers who want interactive cable solutions that enable new subscriber services—and the business opportunities those services provide—don't have to wait any longer.

Working together, Liberate Technologies, a leader in consumer software solutions that integrate television and the Internet, and Cisco Systems, Inc., the worldwide leader in networking for the Internet, have developed interactive cable solutions that will operate with your existing cable infrastructure and equipment. Liberate and Cisco are offering cable providers deployment-ready solutions that will change how you do business.

A New-World Solution for A Real-World Need

A scalable interactive cable solution has almost unlimited potential to impact the way people work, live, play, and learn. New, interactive cable service offerings, based on the right solution, can provide products and services through cable infrastructure already in use, directly connecting the consumer awareness that broadcast cable creates to actual purchases.

Interactive solutions have always posed the following challenges:

- How to deliver multiple services (data, voice and video) in a single, cost-effective medium
- How to create compelling services for consumers
- How to generate additional revenue from these services for cable operators

In the last few years, cable operators have wanted to find a way to merge information, entertainment, and business in a single medium in the home. Connecting broadcast to the Web can become that single medium. Working together, Liberate and Cisco deliver the cost-effective link connecting cable to the World Wide Web. Their vision has been simple: to enable new business opportunities through interactive cable services, while allowing cable operators to retain full control of their network, branding, and the look-and-feel of these new services.

Deploying the Liberate and Cisco interactive cable solution with cable's high-speed, two-way channel, cable operators can enable interactivity in a broad range of applications, including residential Internet access, personalized program delivery, video on demand, targeted advertising, e-commerce transactions, Internet telephony, and telecommuter network access.

Designed Open: A Solution Based on Standards

Key to any large-scale solution in the cable space, standards provide published common interfaces and protocols, enabling rapid application growth and sustainable competition—leading to better, lower-cost options for cable operators and subscribers.

The two key standards for delivering end-to-end interactive cable services are the Data-Over-Cable System Interface Specification (DOCSIS) and the Advanced Television Enhancement Forum (ATVEF) specification. Cisco and Liberate both endorse a standards-based approach. The Cisco involvement in DOCSIS and the Liberate involvement with ATVEF means that both standards are built into the Liberate/Cisco Interactive Cable Solution.

DOCSIS

Liberate designed its TV Navigator for DTV Client to work with the DOCSIS standard, ensuring an open, flexible, long-term solution for subscribers. In the past, protocols for data over cable have been proprietary, giving consumers narrow purchasing choices. Consumers haven't been comfortable about buying equipment solely focused on one cable system or format. Fortunately, over the last several years, a standard has emerged for delivering data over cable. DOCSIS, a fully interoperable standard, is supported by numerous headend vendors and dozens of cable modem and set-top box vendors. It enables interoperability between their many products. Originally developed by CableLabs in North America, the DOCSIS standard is enjoying worldwide interest. Deployments with DOCSIS are now under way in virtually all parts of the world, including Europe and Asia. The ITU has endorsed DOCSIS and created the J.83 data-over-cable international standard, identical to DOCSIS. CableLabs certification to ensure interoperability of DOCSIS cable modem (CM) and cable modem termination shelf (CMTS) is under way. The Cisco universal broadband router (uBR 7200 series) is the first CMTS to be qualified by CableLabs.

With the overwhelming support that DOCSIS is enjoying in the marketplace, silicon vendors are applying silicon chip economics to dramatically reduce the cost of DOCSIS-based devices. Products based on second-generation silicon from Broadcom (BCM3300 chip) are already available, and work is already under way on third-generation silicon that will further reduce the cost of building DOCSIS devices. Several other silicon vendors are also working on low-cost, integrated DOCSIS solutions.

Compliance with the DOCSIS standard means that both vendors and their customers enjoy high bandwidth over a two-way channel, quality-of-service capabilities that give cable operators control of their networks to charge for different tiers of service, and scalability for flexible growth.

ATVEF

The Advanced Television Enhancement Forum Specification (ATVEF) is the result of a cooperative standardization effort of a cross-industry group formed to specify a single public standard for delivering interactive television experiences that can be authored once and deployed to a variety of television, set-top, and PC-based receivers. The component technologies emphasized by ATVEF, Hypertext Markup Language (HTML), and ECMAScript/Javascript, are the cornerstones of a standards-based interactive television system that can be used for Internet services on television or for enhanced television services linking video to data content. The ATVEF standard is supported by many leaders in all key parts of the media creation and distribution value chain—from content owners and enhancers, such as Sony and Discovery, to cable operators such as TCI (now AT&T).

ATVEF is also working on harmonizing standardization efforts with key global standards-setting bodies, including:

- OpenCable
- ATSC: Advanced Television Systems Committee
- DVB: Digital Video Broadcasting
- ARIB (Japan)
- SMPTE: Society of Motion Picture and Television Engineers
- W3C: World Wide Web Consortium

How? Next-Generation Architecture Leveraging Existing Cable and Network Infrastructure

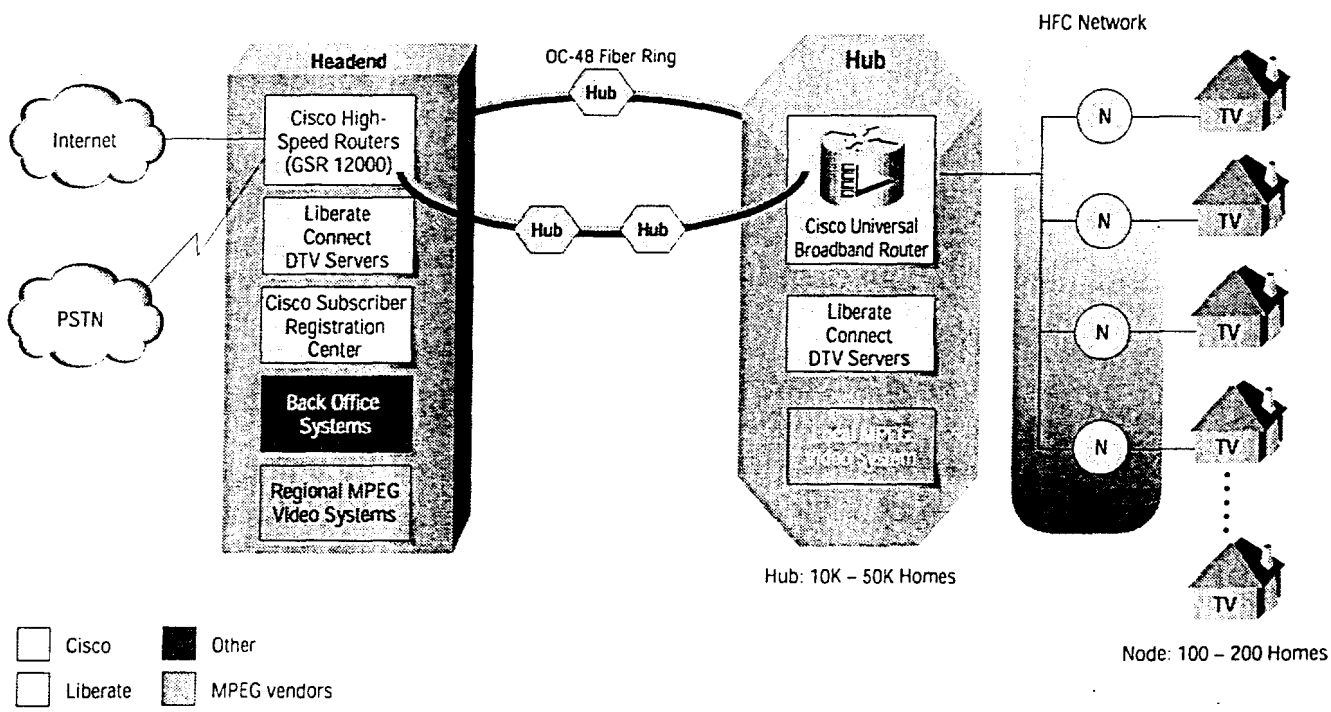
Before we tell you about the power and possibilities of the Liberate/Cisco solution, we'll show you just how this scalable, reliable, manageable solution works: a state-of-the-art, end-to-end, next-generation architecture that leverages cable providers' existing infrastructure.

The interactive cable service solution architecture has four subsystems that, when working together, enable the delivery of interactive cable into homes. Those subsystems are the high-speed fiber backbone now deployed by cable companies; the headend, aggregating content at the national and regional level and sending it to the fiber backbones; the hub, combining regional programming with local content and sending that combined content to the cable network; and the interactive set-top box, connecting subscribers to the cable network with the two-way, broadband pipe.

The Backbone

You're already familiar with the backbone (Figure 1). It's a high-speed, digital network that carries Internet data, voice, and video between cable company facilities—regional processing centers, headends, and hubs. Cable operators are well positioned to build a converged IP network because of the strong regional fiber available to them. This fiber backbone is made of OC-3 (156 Mbps) to OC-48 (2488 Mbps) Synchronous Optical Network (SONET) or Asynchronous Transfer Mode (ATM) rings, enabling scalability as more and more data travels over the backbone. The backbone network also has connections to other networks, including the Public Switched Telephone Network (PSTN), to other cable system backbones, and to the public Internet interconnect points used by other Internet service providers.

Figure 1 The Backbone Network



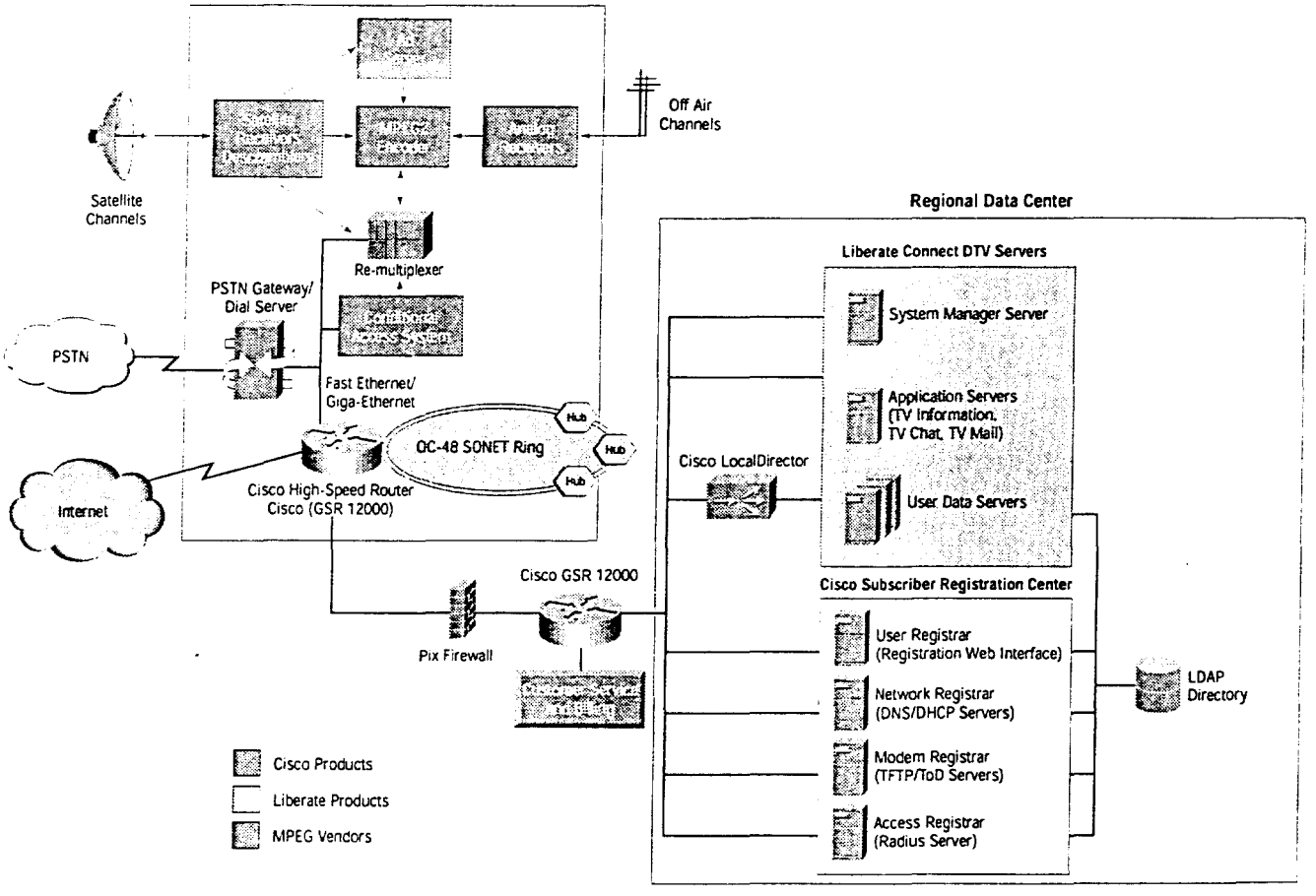
Because of the tremendous need for IP bandwidth on the Internet and other large IP-based networks, new technologies that allow IP packets to be efficiently and reliably transmitted over fiber have emerged. Instead of connecting to time-division multiplexing (TDM) equipment, high-speed routers with optical internetworking capabilities can now be connected directly to fiber and other types of optical transmission systems. Optical internetworking reduces hardware costs by eliminating separate TDM multiplexers that use wasteful static and fixed bandwidth allocation. Optical internetworking statistically multiplexes the full optical capacity of fiber for more efficient bandwidth usage. With few devices to operate and manage, optical networks are easier and less costly to maintain.

The Cisco gigabit switch router (GSR) 12000 enables an IP layer directly over the optical infrastructure. The GSR 12000 delivers Cisco dynamic packet transport (DPT) technology, combining the bandwidth-efficient and services-rich capabilities of IP routing with the bandwidth-rich, self-healing capabilities of fiber rings to deliver fundamental cost and functionality advantages over all other existing solutions.

The Headend

The headend brings national and regional content—satellite video, off-the-air video, Internet backbone, and PSTN voice and dial access—into the cable network, and transforms them to be carried over the backbone (see Figure 2). The regional data center is often located at the headend, sharing the Internet backbone and PSTN connection, although it can also operate as a separate hub on the fiber ring, depending on the deployment size.

Figure 2 Headend Architecture



Cisco provides high-speed routers to route interactive traffic between the backbone and Ethernet in the headend internal network. Signaling protocols maintain the network intelligence needed to route this traffic optimally, automatically building and maintaining the routing tables to direct traffic and signal failures for rerouting in the network. Border Gateway Protocol (BGP) operates between the cable operator's regional network and external networks, providing routing information exchange between different networks. The Open Shortest Path First (OSPF) protocol is used internally in the regional networks.

Cisco also provides a true end-to-end networking solution that incorporates Cisco IOS® software, an operating system that lets cable operators use all of the advanced Cisco software features, including quality of service, Weighted Fair Queuing, and IP multicast. Cisco IOS software enables consistent, manageable service and policies across all Cisco networking products. These software features also give cable operators the ability to add new customer-billable features whenever they need to, guaranteeing faster time to market to add new services and greater revenue potential.

The Data Center: The Cisco Subscriber Registration Center and Liberate Connect DTV Servers

The data center is the location for subscriber registration and network connection. Getting subscribers on line quickly is important when deploying interactive cable services. To enable set-top box connection into this network, two things need to happen: provisioning, resource reservation, and configuration management must be automated and interoperable set-top boxes must be available.

The Cisco Subscriber Registration Center (CSRC) is a complete solution for data, voice, and video service provisioning for broadband networks. It consists of four key elements: the Network Registrar (the Domain Name System [DNS] and Dynamic Host Configuration Protocol [DHCP] servers), Modem Registrar (the Trivial File Transfer Protocol/time-of-day [TFTP/ToD] servers), Access Registrar (the Remote Access Dial-In User Service [RADIUS] server), and User Registrar (the user interface for registration), interfacing to a common directory. CSRC can scale to millions of users without significant retooling. It offers subscriber self-provisioning capabilities, carrier-grade reliability, and complete application programming interfaces (APIs) for business system integration. These APIs enable data, voice, and video services provisioning systems to share common user and service information using a standards-based Lightweight Directory Access Protocol (LDAP) directory scheme. For example, these APIs enable the Liberate User Data Server to communicate with the CSRC directory to get information on IP addresses, user names, subscription levels, and more.

After registered subscribers get an interoperable DOCSIS-compliant set-top box, they plug it into the broadband cable network. Automatic configuration begins when the cable modem in the set-top is detected and the CSRC DHCP server establishes IP connectivity and the basic IP configuration. As part of this initialization, the DHCP server transmits to the client set-top, binding information for other resources, such as ToD server and TFTP servers. When using this initial configuration, the DOCSIS cable modem uses TFTP to download its default DOCSIS configuration, such as the DOCSIS options associated with that set-top vendor, subnet, and CMTS. When minimally configured, the set-top will register with the Cisco uBR 7200 and create an associated object in the LDAP directory. The subscriber can now access the User Registrar Web User Interface (UI) to select one or more of the service packages offered by the cable operator.

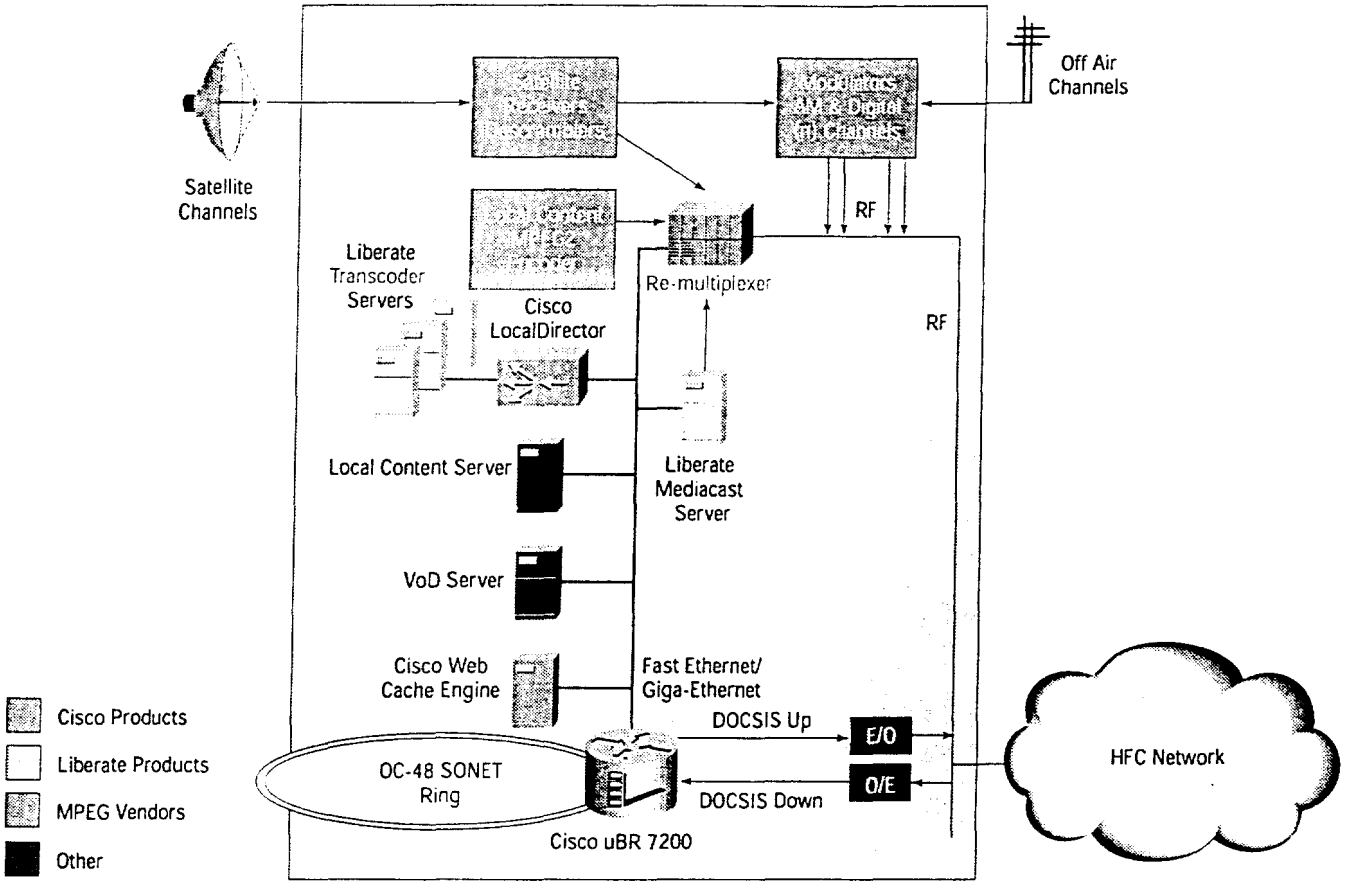
The "Liberate Connect DTV Suite™" provides or services Internet-enhanced video service, integrating servers, tools, and applications that enable cable operators to deliver cost-effective, branded, centrally managed services through set-top boxes. The Liberate servers at the Data Center includes the Connect DTV Application servers, User Data servers, and the System Manager server.

The Connect DTV Application servers include TV Mail, TV Info, and TV Chat. The User Data servers store user account and access information. They support multiple users for each set-top box, and support Hypertext Transfer Protocol (HTTP) cookies, local user data, preferences, and properties. The User Data servers also manage subscription-based services and create billing events. The System Manager provides centralized configuration management. Through standard CORBA/IIOP interfaces, the User Data and System Manager servers communicate with existing cable subscriber and management systems. This facilitates integration and speeds service rollout. To allow subscriber scalability, the Cisco LocalDirector balances the load between user traffic and controls fail-over across multiple Liberate User Data servers.

The Hub

Hubs contain equipment that converts content from the backbone format—IP over optical—whether the service is data, voice, or video, to the hybrid fiber coaxial radio frequency (HFC RF) format. Hubs can also receive local off-the-air video streams in analog form or digital video from satellite feeds (see Figure 3).

Figure 3 The Hub Architecture



Liberate Hub Components: the Liberate Transcoder Server and Liberate Mediacast Server

The Liberate Transcoder server transcodes HTML, images, and audio in a flexible manner, letting the DTV client access standard, rich Internet media, while meeting processing power and memory limitations. It also acts as an HTTP/HTTP Secure (HTTPS) gateway to obtain Web pages for the DTV clients. It supports a broad variety of standards-based interfaces, including HTTP/S to both unsecure and secure external Web sites for electronic commerce, Simple Network Management Protocol (SNMP) to the operator console for management, and Extended Markup Language (XML) to the System Manager. Included in the Transcoder server are security functions: a Secure Sockets Layer (SSL) gateway and secure communications between the client and the HTTPS gateway, supported by both 40- and 128-bit encryption. The Transcoder provides high bandwidth interactive sessions using the DOCSIS channel. It also transcodes material that is eventually broadcast through the Mediacast server. To achieve scalability, Liberate servers work with the Cisco LocalDirector to balance user traffic loads and provide fail-over across multiple servers.

The Mediacast server supports data carouseling for in-band, Motion Picture Experts Group (MPEG)-2, broadcast delivery of enhanced TV content, popular Web sites and TV information. IP multicast is also supported through DOCSIS. Mediacast supports push and pull models for updating carouseled content. For Web content that is broadcast to all subscribers, it stores and forwards carouseled content at predefined times and performs program identifier (PID) multiplexing and time stamping to create a standard MPEG-2 multiprogram transport stream.

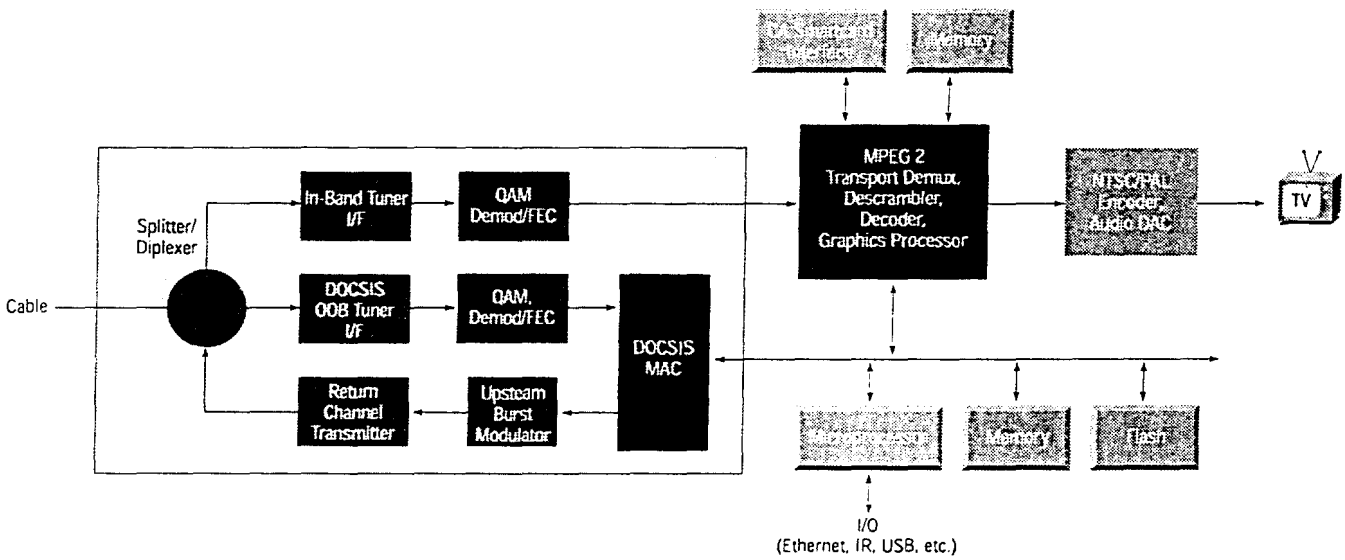
IP Network: Cisco uBR 7200

Key to the hub architecture, the Cisco uBR 7200 universal broadband router combines the functionality of the industry-leading Cisco 7200 router and a headend CMTS in one integrated platform. The Cisco uBR 7200 provides cable operators with a cost-effective, scalable, and feature-rich interface between subscriber cable modems and the backbone data network. The uBR allows cable operators to choose the number of broadband CMTSs per chassis (depending on its deployment size) and the kinds of networking interfaces (depending on the network design of its cable infrastructure). Deploying the Cisco uBR 7200 in the hub architecture guarantees integrated routing, universal product design, and assured interoperability. To ensure optimal operation, Cisco has designed and tested the multifunction Cisco uBR 7200 as a complete system. The Cisco uBR guarantees high performance, security, quality of service, scalability, and bandwidth management—all the features that come with the Cisco core networking technology, Cisco IOS software.

The Interactive Set-Top Box

The set-top box is a consumer device that receives the signals from the cable network and displays them on a television. A set-top box with DOCSIS cable modem functionality allows high levels of two-way interactivity. Inside the DOCSIS set-top box are two tuners. One handles MPEG-2 video, audio, broadcast control data, and broadcast service data. The other supports DOCSIS IP data. The return path can be implemented with DOCSIS, providing much higher bandwidth than telephone return (see Figure 4).

Figure 4 Set-Top Box Hardware Architecture



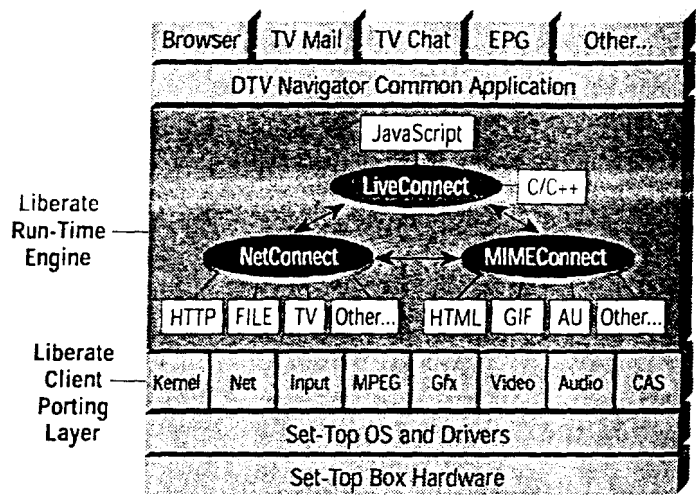
With higher levels of integration, chip manufacturers are already shipping single-chip integration of the QAM demodulator, forward error correction (FEC), upstream modulator, and the DOCSIS Media Access Control (MAC).

After the MPEG-2 transport stream is de-multiplexed, the entitlement management messages (EMMs) and entitlement control messages (ECMs) are stripped out and processed by the conditional access (CA) smartcard to obtain the control word (key) to de-scramble the MPEG-2 video streams. The video stream is then decoded and combined with Web pages and other on screen displays by the graphics processor and then displayed on the TV.

Web pages and other IP data are sent down the DOCSIS channel out of band from the video, so that video quality and the number of video channels available are not affected by the IP traffic. They are then processed by the Liberate DTV client software and displayed with the video. The Javascript platform also allows addressability, targeting, and interactivity.

The set-top box and headend cable router all contain a consistent and interoperable suite of standards-based protocols that support configuration, security, multimedia, quality of service, and management for the DOCSIS channel. The Cisco uBR enables the delivery of all these features, end to end, throughout the cable network.

Figure 5 TV Navigator for DTV



Beyond hardware architecture and the fundamental software components, the Liberate-enabled set-top box offers application layers that merge video broadcast and Internet access into a seamless, highly flexible user interface. This on-screen interface allows cable subscribers to view standard and premium video offerings, browse the Web, send e-mail, engage in TV chat, engage in e-commerce, and connect opportunities presented through the broadcast portion of their session with related, publicly available Web-based content.

Figure 5 shows how TV Navigator for DTV layers over set-top hardware and provides the software platform for interactive services.

When implementing the Liberate TV Navigator Client, it's important to remember its flexibility and memory-saving design. Its minimum memory requirements include 700K of persistent storage, 800K for volatile memory, and an 8-bit graphics capability. Full-featured operation requires one megabyte each for persistent storage and volatile memory, and support for 16-bit graphics. It's also much easier to author Web content for this solution. Based on open, standard HTML and Javascript, rather than C++, it's easier to create, mount, and brand.

Open for Business: A New World of Opportunities for Cable Operators

In the past, cable business and its physical infrastructure was based on content delivery with analog signals. Starting now, the opportunity for cable operators will be an extended combination of offerings using digital signals over high-speed broadband HFC networks, extending traditional video content delivery to include Internet access and interactivity with IP-enabled digital signals.

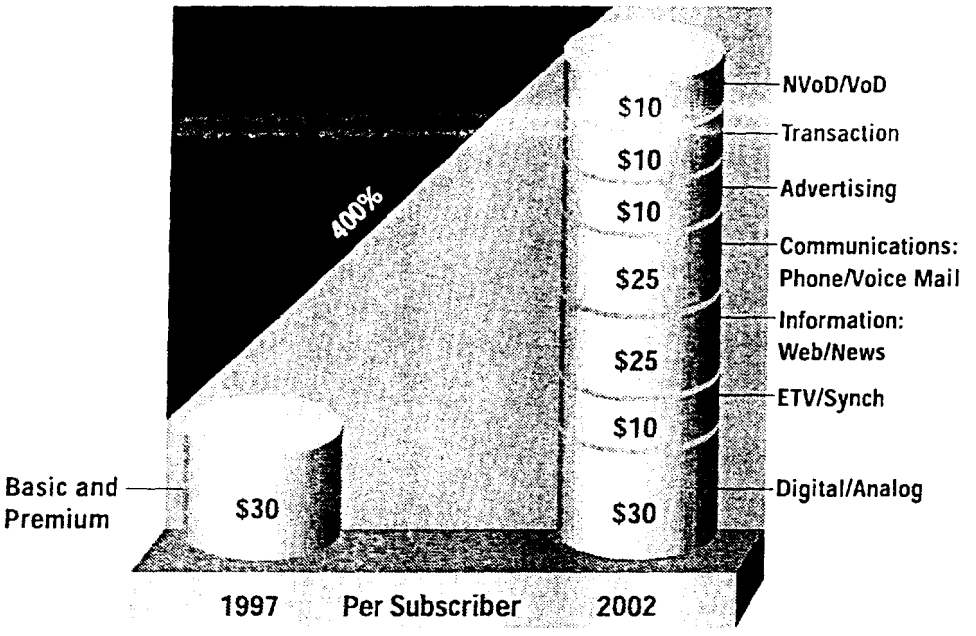
This combination of digital infrastructure and new services delivery can provide significant revenue with high profit margins from your existing subscriber base while opening new subscriber bases.

With regard to the interactive solution and cable operators, three areas stand out as opportunities for cable operators' bottom lines, today: higher subscriber revenue, lower subscriber churn, and higher operational efficiency.

Higher Subscriber Revenue

An interactive cable solution can offer cable operators higher subscriber revenue over their existing broadband infrastructure. Figure 6 shows that on top of basic programming revenue averaging $30 per month, cable operators can realize an additional $35 for informational access and enhanced TV, plus another $25 (or more) for communications services. Also, targeted advertising and e-commerce can add an additional $20 and finally another $10 for video-on-demand (VoD) or near-VoD (NVoD) services. These new services add at least $90 monthly, per subscriber, over the monthly revenue cable operators collect now. It doesn't even cover the additional revenue cable operators can collect from support for third-party services, including preferred hosting, brokering interactive links, and site referrals.

Figure 6 New World Opportunities



Lower Subscriber Churn

Studies from cable operators who have rolled out initial interactive services discovered that they are realizing lower subscriber churn. Interactive content creates more personalization for the subscriber and richer content, resulting in higher customer loyalty. This type of retention reduces the customer acquisition cost and time to market for new services for the cable operator.

Higher Operational Efficiency

Network convergence means minimum equipment types and subsystems, both in the cable operator's network and in the subscriber's equipment. There is, for instance, only one type of data handling equipment used in the headend to support all these new interactive services. Similarly, one subscriber device can support all these services.

Common equipment will lead not only to reduced purchase and operations cost, but also to a new service: an interactive TV system built with open standards, an existing infrastructure, content, and tools. No new technologies need to be developed, and existing equipment can be used as the network evolves. Incremental technology deployments will leverage existing investments so the payback period for the cable operators is, in most cases, less than a year. In addition, standards-based IP services allow for self-provisioning, making it faster and easier to sign on and administer new subscribers.

In addition, analysts predict a proliferation of devices in the home (see cover story of *Business Week*: "Beyond the PC," March 8, 1999.) Some devices, such as an advanced interactive set-top box or modern PC, will be able to manipulate data, voice, and video. Others in the home may be data only (for example, an e-mail "appliance"), or voice only (for example, a telephone). A converged network strategy centered on IP makes it easier for cable operators to seamlessly address various devices in the home, positioning cable operators to provide services to future home devices. The key to multiple device delivery is broadband availability and open interoperable standards. Cable operators are in the best position to provide broadband availability. Standards, such as DOCSIS are emerging for IP infrastructure and application delivery. As a result, the market for digital set-top boxes and other information appliances that enable interactivity will grow rapidly in the next few years.

Putting It All Together: Interactive Cable Solutions

The following sections show how two of the most important applications, enhanced TV and targeted advertising, work in the Liberate/Cisco interactive cable solution.

Enhanced TV

Figure 7 (on page 11) shows an example of enhanced TV service where a subscriber initially tunes into the golf channel. The Liberate subsystem receives the standard TV transmission, and the Mediacast server opens a data channel out of band, sending an ATVEF announcement. The subscriber sees a "hot button" on the screen, triggered by ATVEF, enabling a crossover link to a standard URL.

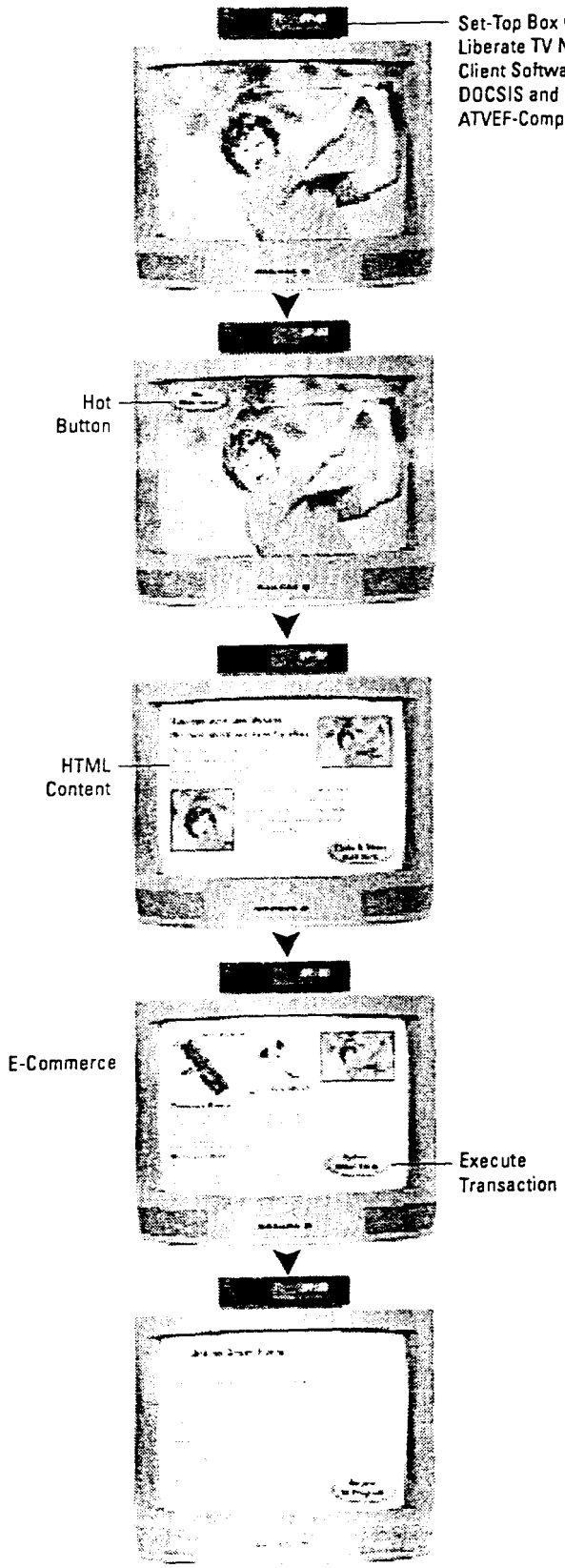
When the subscriber clicks on the hot button with a remote, upstream IP communication moves through the DOCSIS channel. A crossover link is activated and the video window shrinks to an HTML-based window. The transcoder server receives the request, and through an HTTP gateway, retrieves the requested content from cache or from the Internet.

Through the downstream DOCSIS IP communication, the subscriber receives rich HTML content through the Transcoder server, where content is reformatted for the Liberate TV Navigator client software. Included at this point are parental checks and content control. The content is cached in the Transcoder server, and then sent to the set-top box.

Now, as the subscriber surfs the Web, upstream and downstream high-speed data traffic is carried in the DOCSIS channel. The subscriber decides on a purchase, and SSL—through the Transcoder server—is enabled. A standard, secure, Internet-based transaction follows; it includes all data and information exchange that standard Internet transactions contain—but always processed and reformatted through the Transcoder for the Liberate client, and displayed on the subscriber's television screen.

The subscriber finishes the transaction, and presses a button to return to regular programming. The SSL links are closed, the user behavior is logged into the user databases, and Javascript maximizes the television window, enabling the golf TV channel to occupy the entire screen again.

Figure 7 Enhanced TV—Golf Channel Example



Targeted Advertising

Figure 8 (seen on page 13) illustrates a targeted advertising application. While the television is on, tuned to any channel, an electronics store commercial comes on—complete with a "hot button" to signal enhanced ad content. The Mediacast server, on standby alert, receives an announcement through the advertising scheduling system transaction notification.

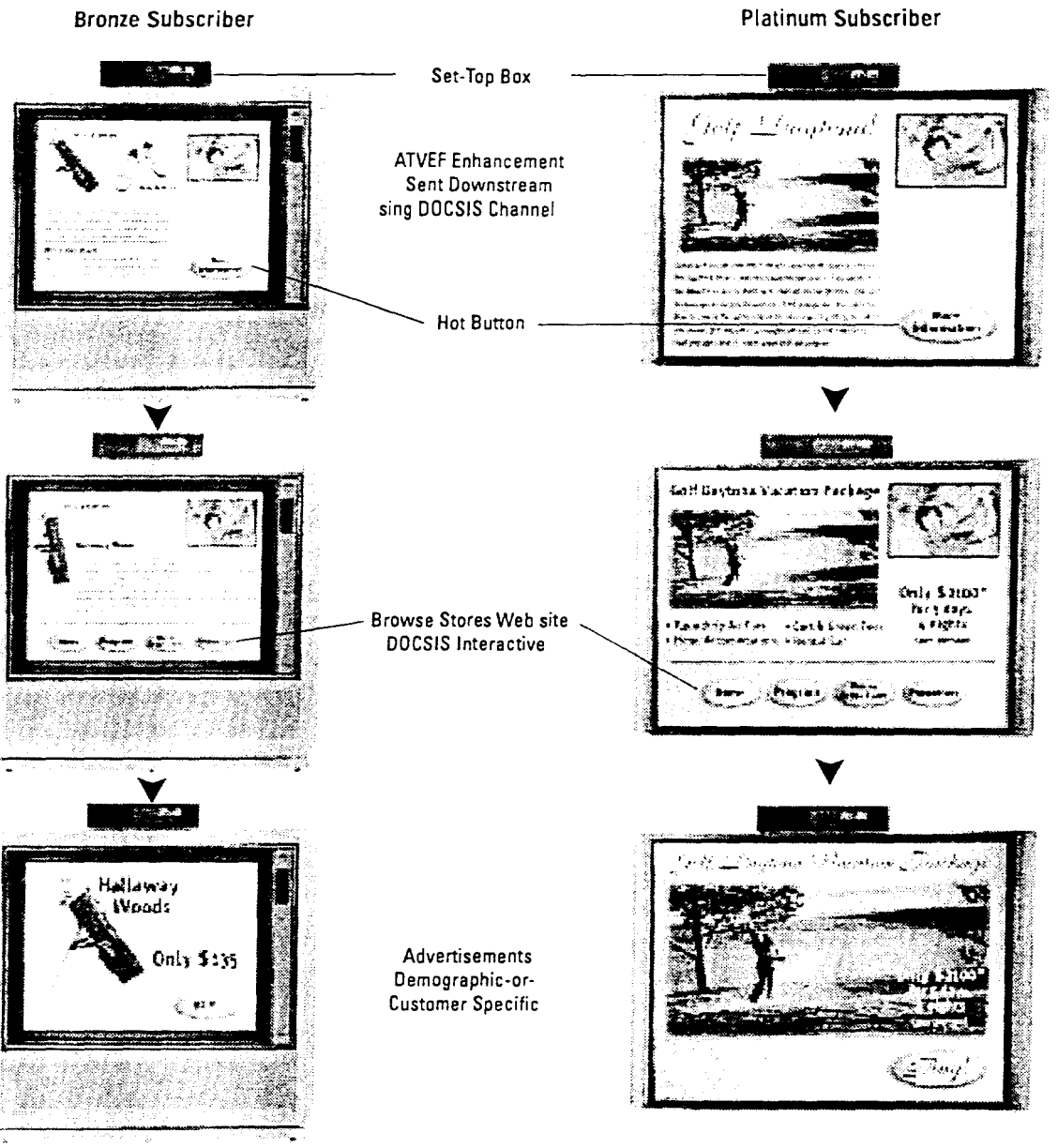
One subscriber presses the "hot button" to go to the enhanced content. Two-way network communications enable a Javascript trigger, which identifies this user as a "Bronze Subscriber", based on User Data Server information. With this information, an economy-priced item is promoted, while the ad continues to play in the television window.

A second subscriber presses the "hot button." This subscriber's User Data Server information identifies him as a "Platinum Subscriber", and plays out a premium-priced item promotion while the ad continues in the television window.

If either subscriber decides to buy the promotional item, an SSL-secured link is enabled to continue and complete the transaction before returning to standard programming.

What enables the distinction between the bronze and platinum subscribers is Liberate's User Data server, and its ability to communicate with the CSRC, where demographic information was stored in the CSRC's directory when the subscriber registered for cable service.

Figure 8 Targeted Advertising



Look to Liberate and Cisco for Your Interactive Cable Solution

Working together, Liberate and Cisco have enabled the kind of interactive solution that does what cable operators need it to do. The solution is ready for deployment today and it works with existing cable infrastructures.

The solution is open, standards-based, and leverages state-of-the-art technologies in both IP and television interactivity. It requires no special content creation, relying on video content from standard cable providers and Web-based content, directly from the World Wide Web.

Liberate's Connect DTV Suite of Servers and TV Navigator client software allow content providers to easily develop applications for cable services. Its small client software footprint ensures that interactive capabilities are available on today's set-top boxes. Standards-based DOCSIS cable modem functionality enables high-speed cable services for use with many devices in the home, including PCs, set-top boxes, and other appliances. Liberate's client software enables easy-to-use interactive applications for TV, enabling compelling services that subscribers will pay for and keep.

Cisco provides the end-to-end networking solution to deliver the integrated video and data services. The Cisco GSR 12000 provides high-bandwidth backbone to transport video and data traffic in an efficient manner. The Cisco uBR 7200 provides DOCSIS-compliant CMTS and integrated routing functions for two-way interactivity. The Cisco LocalDirector balances the load of user traffic and controls fail-over across multiple Liberate User Data servers at the headend and Transcoder servers at the hub.

This solution leverages standards-based LDAP directories to provide an interoperable interface for self-provisioning, allowing cable operators fast deployment.

The solution is ***scalable***, so it can grow with your business. It's ***manageable***, so you can control the network and its services. Perhaps most importantly, it's ***reliable***: you can ensure that your services will be "always on."

For more information, contact either Cisco or Liberate to learn more about this exciting, ready-to-deploy, interactive cable solution at: www.cisco.com/cable, or Liberate at: www.liberate.com.

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